How to Recognize and Reduce Tree Hazards in Recreation Sites

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Abstract

An understanding of the many factors affecting tree hazards in recreation sites will help predict which trees are most likely to fail. Hazard tree management deals with probabilities of failure. This guide, written for anyone involved in management or maintenance of public use areas that contain trees, is intended to help minimize the risk associated with hazard trees by presenting information on their identification and treatment.

How to Recognize and Reduce Tree Hazards in Recreation Sites

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Introduction

Outdoor recreation offers many enjoyable experiences but there are associated risks, such as the property damage and personal injury that may be caused by falling trees or branches. It is the recreation site manager's responsibility to provide as safe an environment as possible for public use.

If an accident occurs, it may be up to the courts to determine whether adequate precautions were taken to reduce hazardous conditions or whether the accidents resulted from natural causes beyond the manager's control. If managers cannot prove they took reasonable steps to reduce hazards in their campgrounds, they may be found negligent and held liable for the accident.

This guide is intended to help minimize the risk associated with hazard trees by presenting information on their identification and treatment. It is directed primarily at Forest Service personnel responsible for managing developed recreation sites. It should be useful also to others responsible for safety in forested recreation sites, parks, and tree-lined city streets.

The first section of this guide describes factors that affect tree hazards. The next section explains hazard tree inspection, in which trees are evaluated for their potential hazard. The final section discusses treatments that can be used to deal with the hazardous trees found during inspections. A list of references also is provided for those who wish to learn more about hazard tree identification and treatment.

Factors Affecting Tree Hazards

An understanding of the many factors affecting tree hazards will help predict which trees are most likely to fail. A tree failure occurs when a tree, or large part of a tree, falls or breaks off. Hazard tree management deals with probabilities of failure, not with certainties. For example, an overmature silver maple[1] with many large, dead limbs and butt rot has a higher probability of failure than a young, vigorously growing one. The age, species, site, and condition of a tree all influence its relative hazard.

A high probability of tree failure alone is not enough to make a tree hazardous; there must be a nearby "target" that could be damaged or injured if the tree fails.

Target

A target may be a structure, vehicle, or person that could be struck by a falling tree. The value of a target has a direct bearing on the relative hazard a tree represents. A tree falling on a fence is less serious than one falling on a visitor center. A tree that could injure or kill people, such as one leaning over a tent pad, is the most hazardous.

Defective trees near a heavily used campsite or picnic table represent a higher risk than do trees in areas infrequently used by visitors because the **probability** of a person being injured is greater should a tree fail. Hazard trees in such areas should have a high priority for removal or other corrective treatment.

Tree Age

Each tree species has a characteristic life span. Therefore, the risk of tree failure increases as trees reach maturity. The hazard ratings in Appendix A provide a general guide for overall tree hazards based on the age of tree species growing in a recreation site.

Tree longevity should be considered both when evaluating tree hazards in established recreation sites and when selecting locations for new sites. Short-lived species such as aspen, paper birch, and jack pine should be avoided unless plans are made to regenerate or replace these species as they reach maturity.

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[1]Scientific names of trees given in Appendix A.

Structural weakening of wood due to decay is a major cause of tree failure. Many species of fungi cause decay and each produces a characteristic type of reproductive structure (Figure 1). Some, such as conks, are woody and perennial while others, such as mushrooms, are soft and deteriorate after only a few weeks. Their presence on the outside of a tree indicates that there is advanced decay inside the tree.

Figure 1 — Conks, such as these of *Phellinus tremulae* on aspen, indicate extensive internal decay.

Decay often exists without conks. The presence of cracks, seams, butt swell, hollow branch stubs, and large old wounds suggest internal decay. Decay fungi generally require openings in the bark to enter a tree, and these openings indicate that a problem may exist. Reliance on external indicators alone or soundings with an ax to detect decay are unreliable methods, especially when inexperienced inspectors are involved. Sometimes an increment borer must be used to confirm the existence of suspected decay or to determine how much solid wood surrounds a column of decay (Figure 2). This technique

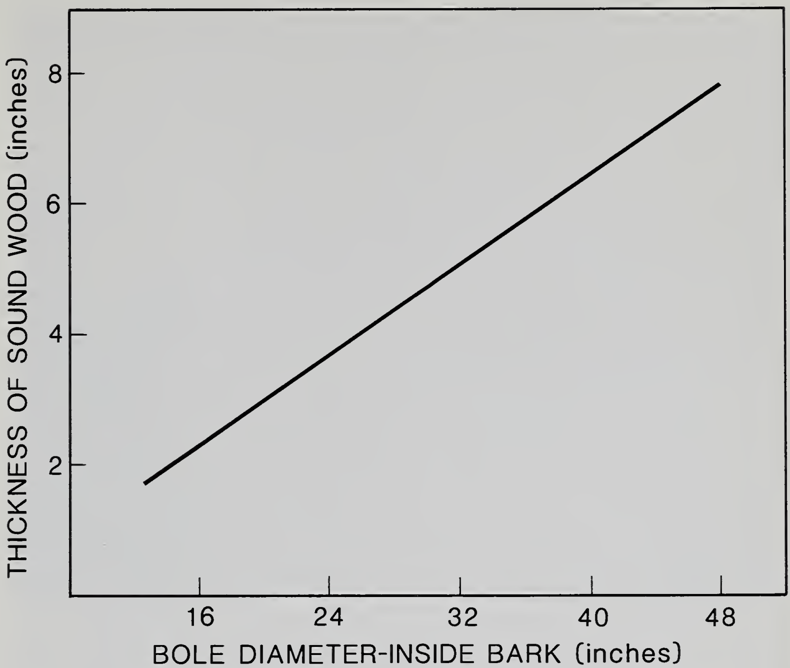

Figure 2 — Thickness of sound wood in outer shell required to maintain 66% of original strength in trees with center rot. If the amount of sound wood exceeds that established by the line on the graph, the tree can be considered relatively safe from failure (Johnson 1981).

should be used only when necessary because the wound created by a borer may provide an entryway for harmful fungi and insects.

Wounds and Cankers

Not only do openings in the bark allow decay fungi and insects to enter trees, but also they can weaken a tree and make it more hazardous. Wounds are mechanical injuries while cankers are localized areas of dead cambium and bark caused by microorganisms, usually fungi.

Large, old, deep wounds are associated with more decay than small, young, shallow ones. Wounds at groundline are more likely to have associated decay than those higher up. Carving wounds made on thin-barked species such as aspen, birch, and beech can seriously injure trees (Figure 3).

Figure 3 — Initials carved in bark allow entry of diseases and insects that can further injure trees.

Because cankers are caused by a living organisms, they often continue to enlarge year after year (Figure 4), while a wound may begin to callus over soon after it is made. Some main stem cankers continue to enlarge until the tree is girdled. Wounds and cankers can be weak points on a trunk and their position relative to the direction of prevailing winds influences the risk they represent. A tree is more likely to break at a wound or canker if it is either facing or opposite the direction of the prevailing wind. Most trees fail during winds of greater than 40 mph, but there always are exceptions. Trees have been known to fall on perfectly still days.

Figure 4 — Common stem cankers: a. Target or Nectria canker (*Nectria galligena)* occurs on many hardwood species.

Figure 4 — Common stem cankers: b. Eutypella canker *(E. parasitica)* occurs mainly on sugar maple.

Figure 4 — Common stem cankers: c. Hypoxylon canker (*H. mammathum*) occurs on aspen.

Seams

A vertical seam in a trunk suggests an internal defect, usually an old wound. The wound creates a weakened place in the wood that is prone to cracking and splitting, especially when the trunk is under stress by winds or abrupt changes in temperature. "Frost cracks" or seams are the outward signs of these internal splits.

Crown Vigor and Form

Crown condition and tree form often indicate the general health of a tree. Crown characteristics that may indicate an unhealthy or unsafe tree include dieback, V-shaped forks, and lopsidedness.

Dieback, characterized by branches in the upper crown dying from the top down, is usually a response to stress (Figure 5). Repeated insect defoliation, drought, soil compaction, or root disease are common types of stress. Secondary pests, such as insects and fungi, are able to invade and further injure stressed trees. Trees can recover from dieback if it has not progressed too far before the source of stress is eliminated (e.g., population of insect defoliators collapses). Trees with advanced crown decline, however, will die and should be removed.

Figure 5 — Dieback of paper birch. Dead branches in upper crown indicate tree is under stress due to such factors as drought, disease, insect defoliation, soil compaction or exposure.

V-shaped forks are weaker than broader angles and are more likely to split. Ice storms, heavy wet snow, or high winds often trigger such a failure. Elm, oak, maple (especially silver maple), yellow-poplar, and willow are especially prone to breakage at weak forks (Figure 6).

Figure 6 — Trunk seam or vertical crack indicates point at which tree is liable to split during windstorm or under heavy snow load.

When trees are removed for a new campsite, crowns of hardwood trees on the edge of the campsite begin to grow into the opening, creating a lopsided crown. Large limbs develop over the campsite and the trees will tend to fall into the campsite should failure occur. Lopsided crowns may develop also along hiking or ski trails and roads.

Branches that break off and become lodged in the crown pose a serious risk because they may be easily dislodged during relatively light winds.

Leaning trees may represent a hazard if the direction of lean is toward a potential target (Figure 7b). Generally, trees that lean more than 15 degrees off the vertical should be removed. Trees that have always grown with a lean are considerably less hazardous than trees that originally grew straight but subsequently developed a lean due to wind or root damage. The general growth form of a tree and any uplifted soil on the side of the tree opposite the lean give clues to when the lean developed.

Root Condition

Roots function both to absorb water and elements and to anchor trees in the soil. If the physiological functioning of absorbing roots is impaired, such as by flooding or root disease, tree vitality and health will be affected. If the mechanical strength of woody roots is reduced by wood decay or serving, wind-throw will be more likely. Wind-firmness is influenced also by soil moisture and depth, with trees on wet or shallow soils being more prone to uprooting.

Above-ground clues to poor root condition include thin crowns with dwarfted, off-color or yellow foliage, reduced height or diameter growth, soil compaction or erosion, construction activities resulting in severed or wounded roots and soil fill around trees, discolored or resin-soaked wood at the root collar, and fruiting bodies of root rot fungi growing at or near the base of the trees.

Most mushrooms growing under trees are not associated with root disease, but generally are beneficial fungi or saprophytes growing on dead organic matter in the litter or soil. Familiarity with the fruiting bodies of the common root disease fungi in the northeastern U.S. is useful during tree hazard inspections (Figure 8a-e). These fungi also often decay wood in the lower trunk of infected trees.

Figure 8 — Fruiting bodies of common root disease and butt rot fungi: a. Honey mushrooms (*Armillaria spp.*) occur on hardwoods and conifers.

Figure 8 — Fruiting bodies of common root disease and butt rot fungi: b. Annosus root rot conks (*Heterobasidion annosum*) occur on conifers, especially pines

Figure 8 — Fruiting bodies of common root disease and butt rot fungi: c. Velvet top conks (*Phaeolus schweinitzii*) occur on conifers, especially pines and spruces.

Figure 8 — Fruiting bodies of common root disease and butt rot fungi: d. Ganoderma root rot conks (*Ganoderma lucidum*) occur on hardwoods.

Figure 8 — Fruiting bodies of common root disease and butt rot fungi: e. Sulphur fungus (Laetioporus sulphureus) occurs on hardwoods (especially oak) and conifers.

Hazard Tree Inspections

Periodic, thorough, and documented hazard tree inspections of developed recreation sites are essential to maintain safe conditions. Annual inspections are required (Forest Service Manual 2333.2), but two per year are recommended — one during the summer with leaves on and one during the dormant season. Severe windstorms usually warrant additional inspections.

Every tree in public use areas with the potential to cause property damage or personal injury should be examined systematically. For example, begin at the bottom of the tree looking for signs of root or butt rot and work up the trunk toward the upper crown, noting anything that makes the tree potentially hazardous. Binoculars are often helpful when examining the upper trunk and crown (Figure 9). Walk completely around the tree so that defects are not overlooked (Figure 7). Document all hazardous trees and determine what

a.

b.

Figure 9 — Careful, close examination of trees during hazard tree inspections is important: a. Ash looks apparently sound: b. With the aid of binoculars, several conks are visible on the upper stem indicating advanced decay.

treatments, whether it be pruning, cabling, or tree removal, is necessary to reduce or eliminate the hazard. Recording apparently non-hazardous trees also is important; in case of litigation involving the failure of a tree with no evidence of structural defects, the inspector or agency may be protected by this "lack of evidence."

Figure 7 — Thorough inspection of potential hazard trees is essential: a. Basswood (arrow) near campsite looks safe from this perspective.

Figure 7 — Thorough inspection of potential hazard trees is essential: b. Moving 90 degrees to the left, same basswood is seen to be leaning directly over campsite.

Figure 7 — Thorough inspection of potential hazard trees is essential: c. Moving another 90 degrees to the left, large hollow in trunk is now visible, indicating advanced decay.

Documenting inspections is extremely important. This can involve a simple notation in the appropriate office file stating when the inspections were done and by whom, or can entail a more detailed written evaluation and map of all trees examined.

Detailed documentation of hazard tree inspections has several advantages over merely noting that they were completed. They can be used:

1) to record recommended corrective action and when these recommendations were completed;
2) to note changes in tree condition during subsequent inspections, even with personnel changes between inspections;
3) as a record of what trees fail, using the characteristics of those trees to predict the type of tree likely to fail in the future[2];
4) as evidence of the frequency and intensity of hazard tree inspections in the event of a court case involving damage or injury; and
5) as a record of costs involved in hazard tree inspections and treatments.

The obvious disadvantage of detailed documentation is that it requires more money and time.

An example of a hazard tree inspection survey from is included in Appendix C. Information recorded in such a survey would include the name of the inspector, date of inspection, map of potential hazard trees, defects or hazards observed for each tree, and recommended corrective action. Follow-up action would be documented when corrections are made.

To determine its relative hazard, each tree with the potential to cause damage or injury would be evaluated according to the target it would hit in the event of failure. It would be evaluated also for structural defects, such as decay and cankers. Trees with multiple defects generally are more hazardous than trees with a single defect. Trees thought likely to fail before the next inspection should be removed or otherwise treated to reduce the risk of failure.

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[2]USDA Forest Service "Report of Tree Failure" can also be used. See Appendix B.

Hazard Tree Treatments

All trees represent some degree of hazard, so the only way to completely eliminate hazard is to remove all trees. This solution, of course, is not acceptable to either the public or recreation site manager. A balance must be found between esthetics and hazard reduction. The cost of treatments and availability of trained personnel also influence the intensity and type of treatment used.

Tree Removal

All dead trees within the range of a target are hazardous and should be removed. These and other designated hazard trees should be removed in a manner that will cause the least amount of damage to the remaining trees. Limbing or topping a tree before felling it can reduce wounding of nearby trees. Wounding the lower trunk and roots of residual trees during skidding should be avoided. Trees are especially prone to such wounds in spring when bark is most easily knocked off. Opening up a stand by removing hazard trees can make the remaining trees more liable to windthrow, sunscald, and dieback. All these side effects of tree removal should be considered when recommending hazard tree treatments.

Pruning, Cabling and Bracing

Several treatments can be used to reduce hazard and still retain the tree. They generally require more specialized equipment and training than tree removal, but saving the tree may warrant the extra investment.

Broken, dead, or split branches should be pruned if they are located near a target area. Artificial support of weak or split V-shaped forks by cabling with wire or bracing with metal rods can prolong the life of a tree while reducing the risk of tree failure. Several recent publications describe the proper methods for pruning, cabling, and bracing trees(Shigo 1980; Shigo and Felix 1980). They provide up-to-date information for anyone performing tree maintenance or evaluating work done by others.

Prevention

The best way to deal with most problems is to prevent them. This can be done by properly selecting and designing new recreation sites and by maintaining healthy, vigorous trees in established sites.

Soil compaction and tree wounding can be reduced by proper placement and construction of roads, parking lots, trails, and campsites. Educating campers about the harm that knife and hatchet wounds can cause trees is as important as enforcing rules against such vandalism.

Sometimes hazard trees become so numerous in an area that the best way to deal with the problem is to remove the target rather than the trees. Occasionally, this may simply involve moving a picnic table or outhouse to a safer location, but in other cases it may require closing a campsite or entire campground.

For further information or training on hazard trees, contact your State forest pest specialist, extension forester, or Forest Pest Management of the USDA Forest Service.

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Appendix A

Hazard Ratings Based on Tree Species Longevity

Tree Species

Scientific Name	Common Name	Age	Rating[a]
Abies balsamea	Balsam Fir	<40	1
		40-80	2
		>80	3
Acer rubrum	Red Maple	<70	1
Acer saccharinum	Silver Maple	70-150	2
		>150	3
Acer saccharum	Sugar Maple	<80	1
		80-200	2
		>200	3
Betula alleghaniensis	Yellow Birch	<80	1
Betula lenta	Sweet Birch	80-200	2
		>200	3
Betula papyrifera	Paper Birch	<50	1
		50-100	2
		>100	3
Carya spp.	Hickory	<80	1
		80-170	2
		>170	3
Fagus grandifolia	Beech	<80	1
		80-170	2
		>170	3
Fraxinus spp.	Ash	<60	1
		60-150	2
		>150	3
Juniperus virginiana	Eastern Redcedar	<70	1
		70-120	2
		>120	3
Liriodendron tulipifera	Yellow-poplar	<80	1
		80-200	2
		>200	3
Picea glauca	White Spruce	<80	1
		80-120	2
		>120	3

Scientific Name	Common Name	Age	Rating[a]
Picea rubens	Red Spruce	<100	1
		100-200	2
		<200	
Pinus banksiana	Jack Pine	<50	1
Pinus virginiana	Virginia Pine	50-80	2
		>80	3
Pinus echinata	Shortleaf Pine	<80	1
Pinus resinosa	Red Pine	80-200	2
		>200	3
Pinus rigida	Pitch Pine	<70	1
Pinus strobus	White Pine	70-175	2
		>175	3
Platanus occidentalis	Sycamore	<80	1
		800-200	2
		>200	3
Populus deltoides	Cottonwood	<40	1
Populus grandidentata	Bigtooth Aspen	40-70	2
Populus tremuloides	Quaking Aspen	>70	3
Quercus alba	White Oak	<80	1
Quercus macrocarpa	Bur Oak	80-200	2
Quercus rubra	No. Red Oak	>200	3
Quercus palustris	Pin Oak	<60	1
Quercus velutina	Black Oak	60-150	2
		>150	3
Salix nigra	Black Willow	<40	1
		40-70	2
		>70	3
Tilia americana	Basswood	<80	1
		80-150	2
		>150	3
Tsuga canadensis	Eastern Hemlock	<110	1
		110-200	2
		>200	3

[a]1=low hazard, 2=moderate hazard, 3=high hazard; ratings based on reported biological, silvicultural, entomological, and pathological rotations.

Appendix B

MASTER FORM

1/1-5 1/2/1-5 Number: ____________

REPORT OF TREE FAILURE ①
(Mechanical break, collapse, or uprooting)

1/1/6 1/2/6 Card: 1
2

REPORTING AGENCY: ____________________ UNIT: ____________________ 1/44-51

(A) Tree and stand

1/7-9 Species: ____________________

1/11-12 Approximate dbh of tree: __________ inches

1/14-16 Approximate age of tree: __________ years

1/18-19 Forest type: ____________________

1/21 Stand age class: ___ Overmature
___ Mature
___ Young-growth
___ All-age

1/23-25 Elevation of site: ____________________

1/27 (B) Class of mechanical failure

___ Upper bole (top half)
___ Lower bole
___ Butt (lower 6 feet)
___ Limb
___ Root, including uprooting

1/29-30 (C) Tree defect or fault leading to failure ②

1/32-30 ___ Rot (trunk, limb, or root)
1/35-36 ___ Sweep
___ Tree dead - snag
___ Fire wound
___ Leaning
___ Lightning wound
___ Mechanical wound
___ Cracks or splits
___ Fork or multiple top
___ Twin bole or basal fork
___ Dead top or branch
___ Widow-maker or hang-up
___ Canker, rust
___ Canker, mistletoe
___ Other: ____________________
___ Unknown or none

1/38 (D) Contributing factors

1/40 ___ Wind
1/42 ___ Snow
___ Erosion
___ Soil - saturation
___ Stream bank erosion
___ Shallow rooting
___ Tree striking tree
___ Other: __________
___ Unknown or none

(E) Time and location of incident 1/52

Approximate hour: ____________________ 1/53-54
Month, year: ____________________ 1/56-59
County: ____________________ 1/63-65
State: ____________________ 1/61-62
Site open for public use: Yes ____ No ______ 1/67

(F) Land ownership 1/69

___ Federal
___ State
___ Other public: ____________________
___ Private
___ Public utility

(G) Site category 1/71

___ Established camp or picnic ground
___ Other established public use site ③
___ Volunteer site ④
___ Marked trail
___ Special use site ⑤
___ Roadside
___ Residence site ⑥
___ Other: ⑦ ____________________
___ Urban

(H) Property or person directly affected 1/73

___ Agency
___ Recreationist
___ Forest industry
___ Permittee-Concessionaire
___ Other: ____________________
___ Contractor
___ Public utility

(I) Consequences

___ Clean-up work required 1/2/80
___ Property damaged: ____________ 1/75,27 29.18
Property loss estimate: $__________ 2/14 18
___ Injuries (Do not give tree values) 177 22/0
___ Medical attention required 2/22
___ Fatalities 1/79-224

.............2.26
..........2/27-31
..........3/33-38
..........2 33-38
..........2:40-42

2/44-78 J) Name of site: ⑧ ____________________
Comments: ____________________
____
____

> Only failures of a size capable of inflicting some damage or injury should be reported. Minor limb failures should not be reported unless they were potentially dangerous. Do not report simple death of a tree or part of a tree unless it resulted in mechanical failure. Trees removed prior to failure should not be reported.

① A report should be made for:
(1) each tree failure involving property damage or bodily injury;
(2) each failure adjacent to permanent recreation facilities, home sites, or other locations where failures are a threat to property, and;
(3) each failure on recreation sites and other high use locations during the season of public use, whether or not the failure causes damage or injury.

② Check only those defects and contributing factors which lead to the actual failure.

③ Other established public use site: Winter sports, beaches, viewpoints, visitor centers, historical buildings, etc.

④ Volunteer site: Undeveloped site with concentrated public use.

⑤ Special use site: Resorts, service facilities, etc.

⑥ Residence site: Agency, private, or permittee-lessor.

⑦ Other: Wilderness area sites, open forest, etc.

⑧ Published analyses will not indicate the source of specific incidents.

If many failures occur in your area, reports may be limited to managed sites normally subject to inspection and hazard control. Where information is available, however, reports from volunteer and other noninspected sites will be of value.

> NOTE: A SEPARATE FORM SHOULD BE COMPLETED FOR EACH INDIVIDUAL FAILURE. Inclusion of more than one failure on a report prevents correlation of data unless all details are identical.

Forest Service Form PSW-4600-3 (Rev 6/75)

Appendix C

EXAMPLE OF HAZARD TREE INSPECTION SURVEY FORM

Recreation Site ____________________

Date ____________________

Inspector ____________________

TREE[1] NUMBER	SPECIES	DBH (in.)	TARGET	DEFECT OR HAZARD[2]							ACTION	
				DEAD	DECAY	CANKERS	SEAMS	CROWN	ROOTS	REMARKS	RECOMMENDED	DATE COMPLETED

1 Number only trees with potential for causing damage; draw map of hazard trees in relation to campsites, buildings, etc. on back of form.

2 For each defect or hazard observed, place check in the appropriate block.